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Packet Technology in Cellular Radio
Ohio State Univ., May 27, 1999.

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PACKET TECHNOLOGY *in* CELLULAR RADIO

The Number of Users in Cellular Systems is Increasing

The Cell Size Must Decrease to Reuse Frequencies More Often

Therefore:

There Are More Hand Offs During a Connection

Packet Technology Can Reduce

1. The Work Performed To Hand Off Between Cells
2. The Probability of Disconnect in a New Cell

CHARACTERISTICS

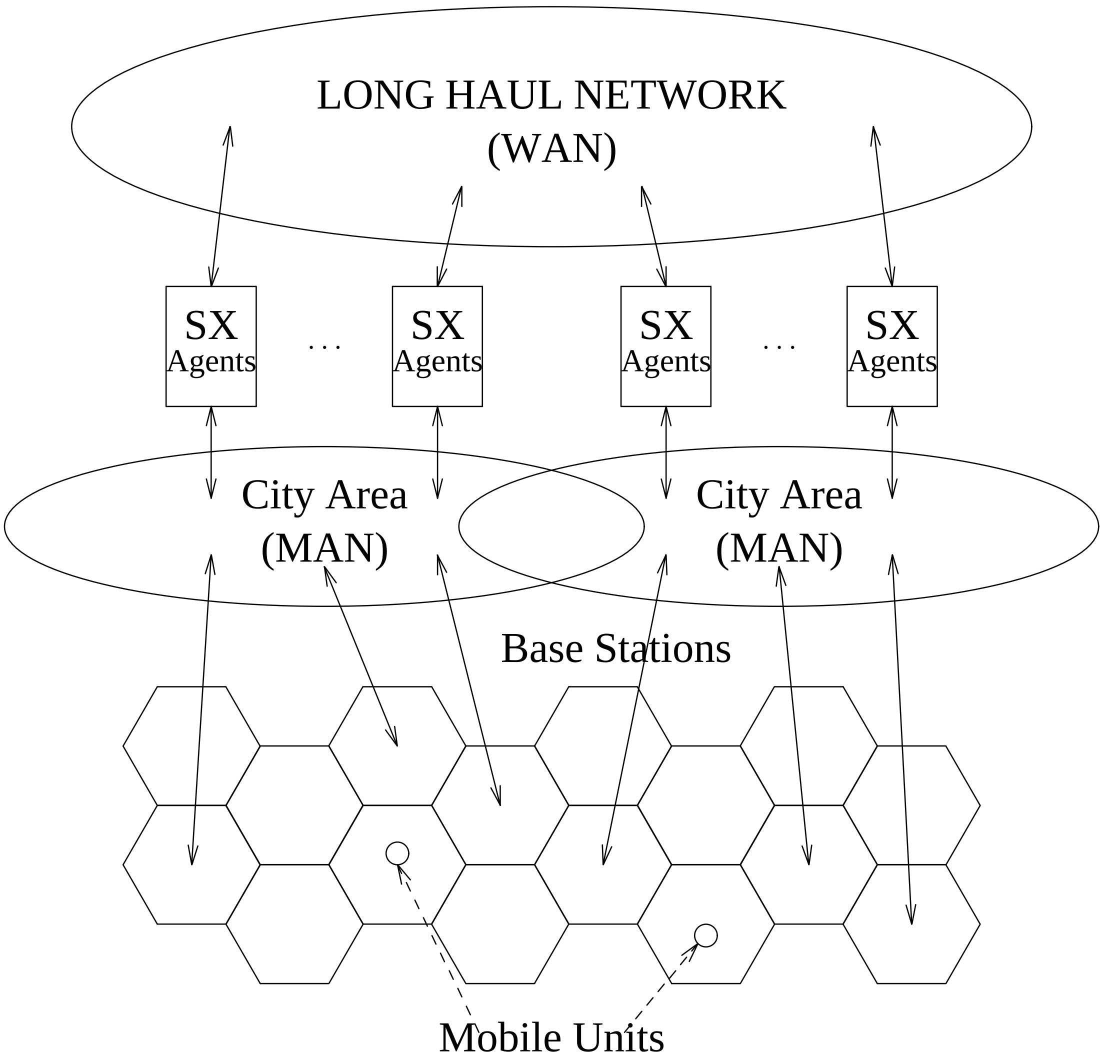
1. **OBJECTIVE: Connect Mobile Units ←→ WAN**
   Not Other Mobile Units
   Implicit Assumption to solve the CDMA Near/Far Problem

2. **Each Cell Has A Base Station**
   - Exercises Control Over Mobile Units
   - Reduces Communication Distance

3. **Smaller Propagation Delay In A Cell**
   - Enables Carrier Sense Contention Protocols

4. **The Wired MAN Is Not The Bottleneck**
   - Bandwidth Is More Restricted In The Wireless Cells
   - Bandwidth Is More Expensive In the WAN

ARCHITECTURE

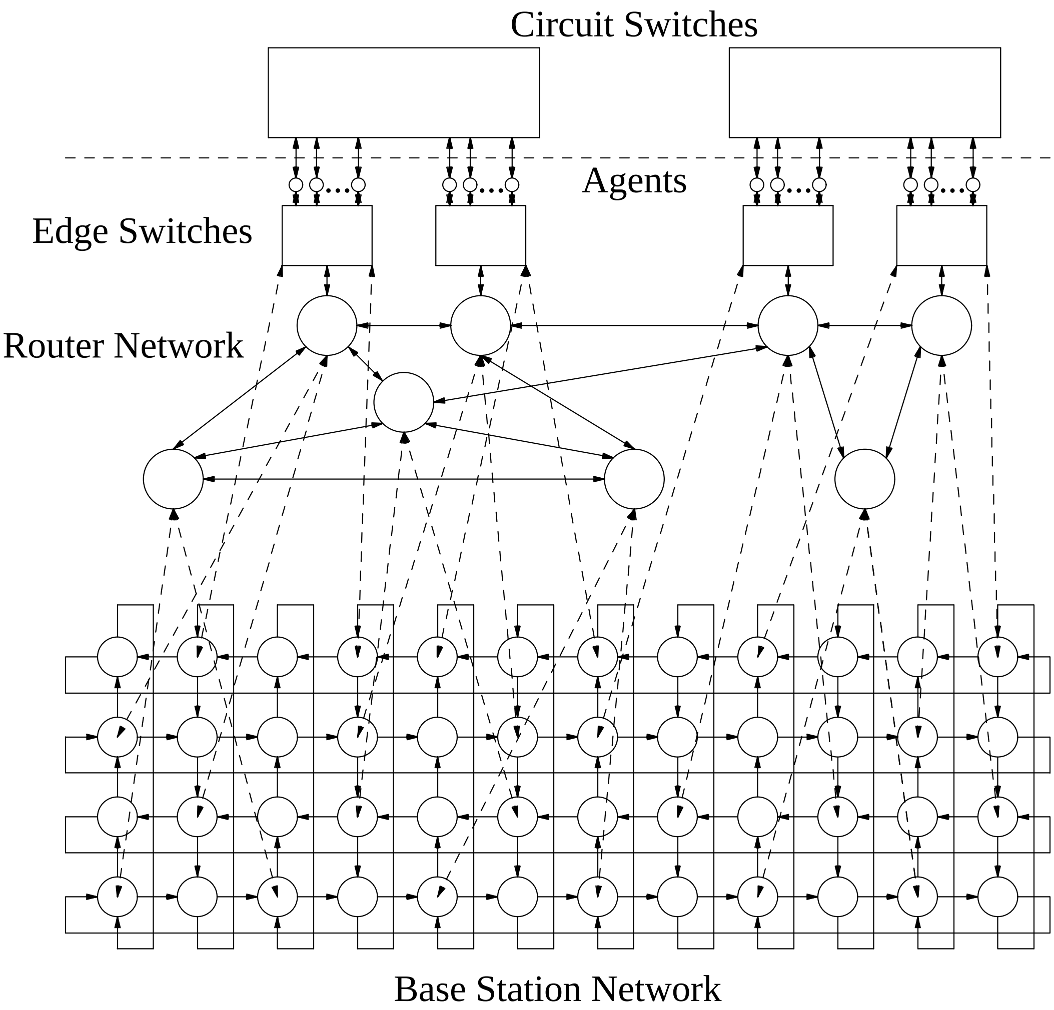


— **A Wired MAN Is Needed To Move Between Cells Without Moving In The Long Haul Network**

— **5 Different Packet Techniques**

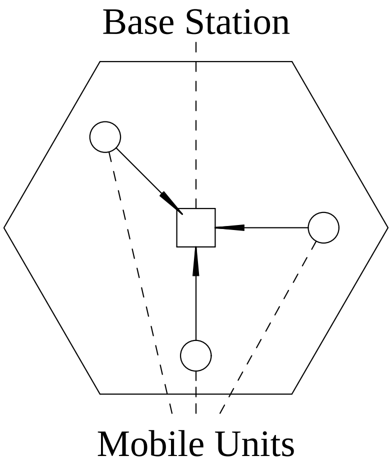
THE WIRED MAN

A LAYERED ARCHITECTURE



APPLYING PACKET TECHNOLOGIES

WIRELESS NETWORK

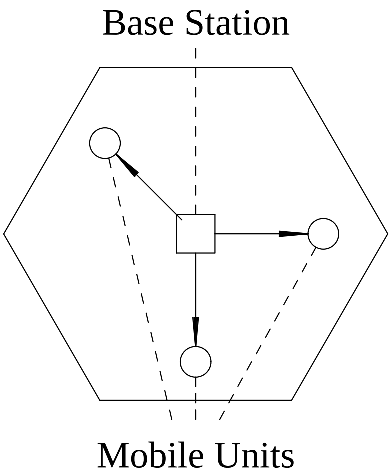


In Bound

Many Mobile Units ⟶ One Base Station

Burst Transmission

Multiple Access, Contention Protocol



Out Bound

One Base Station ⟶ Many Mobile Units

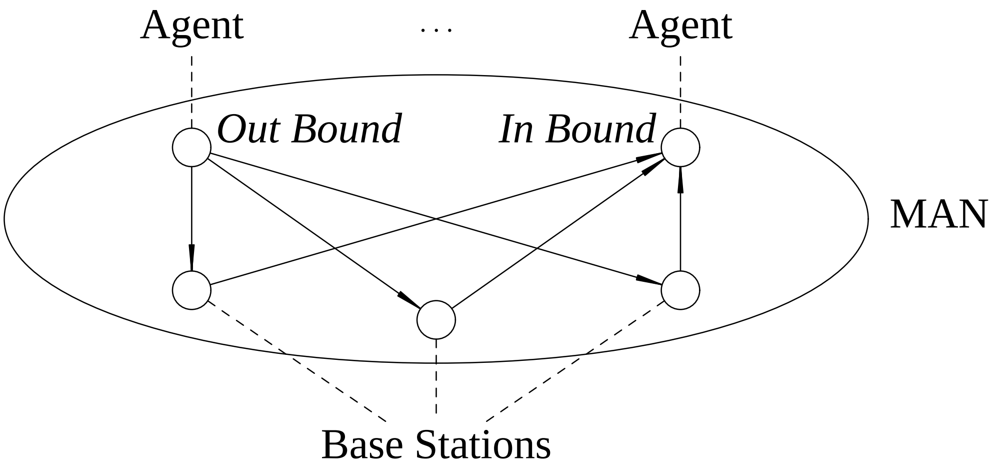
Continuous Transmission

Addressed, *ATM-Like* Slots

APPLYING PACKET TECHNOLOGIES

WIRED NETWORK - *(Packet Routers)*

Assumption: There Is Sufficient Capacity in The Wired MAN to Provide Good QoS Without Making Reservations



In Bound:

Changing Base Station ⟶ Stationary Agent

Packets Have The Same Destination Address

Conventional Router

Out Bound:

Stationary Agent ⟶ Changing Base Station

The Packet Destination Changes As the Mobile Unit Changes Cells

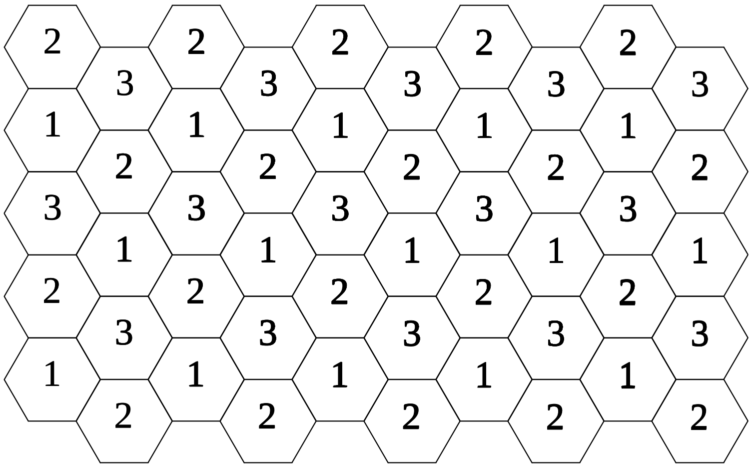
Less Work Than Tearing Down and Setting Up Circuits

APPLYING PACKET TECHNOLOGIES

A COMMON CONTROL CHANNEL -- *Out Bound, Everywhere*

Mobile Units Receive on One Frequency Band

Base Stations Transmit In Different Time Slots
Reuse The Time Slots In Space



FUNCTIONS:

Identify The Closest Base Station

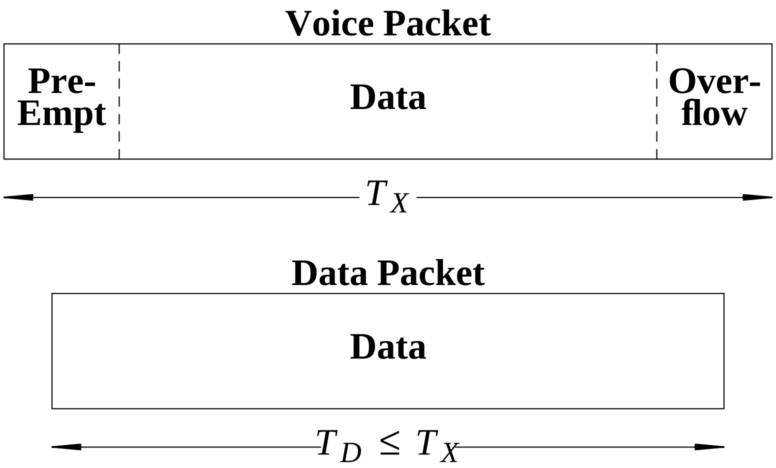
Place A Call To a Mobile User,
Broadcast From An Agent To Locate A Mobile Unit

Information for Mobile Units,
Channel Sets, Utilizations, Acknowledgements

Instructions to Specific Mobile Units
To Constrain Their Voice Bandwidth Or To Change Cells

MOVABLE SLOT TDM

PACKET FORMATS



ACCESS PROTOCOL

DATA and **INITIAL VOICE PACKET**

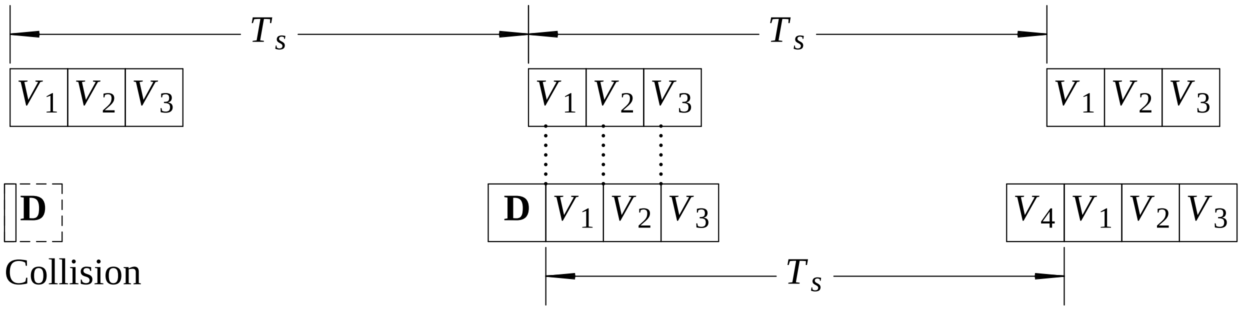
CSMA/CD with Random Retry

PRIORITY VOICE

CSMA with Immediate Retry

Next Packet T_S Secs. After Xmit - *Movable Slots*

MOVABLE SLOT TDM



OPERATION

Priority Voice - Only Delayed By A Packet In Progress

Delay $< T_X$ *(a Packet Xmit Time)*

Two Priority Packets Never Collide

Scheduled $\geq T_X$ *Apart*

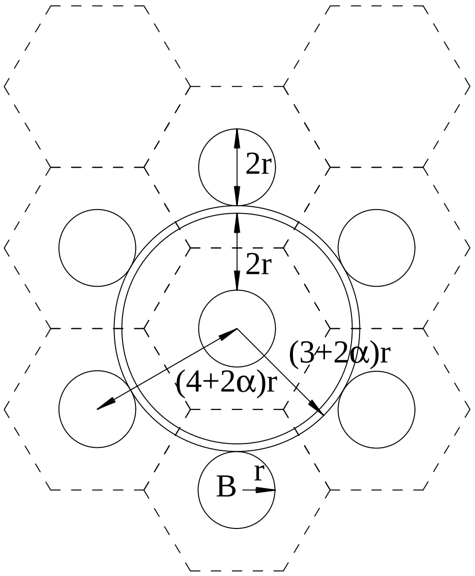
No Voice Samples Are Lost

Even As $\rho \rightarrow 1$ - *Proof*

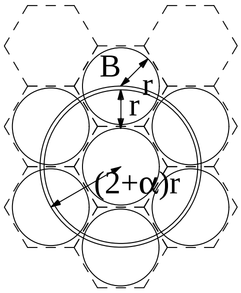
SINGLE VRS DOUBLE CHANNEL CSMA

CONSTRAINTS ON FREQUENCY REUSE

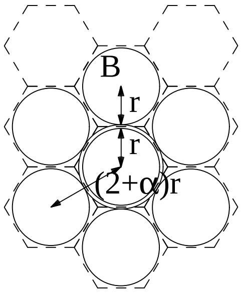
One Channel



Two Channels



Inbound Channel



Outbound Channel

Single Channel: Mobile Unit $\longrightarrow$ Mobile Unit
Office Networks, *Military Systems*

Double Channel: Mobile Unit $\longrightarrow$ Base Station,

Base Station $\longrightarrow$ Mobile Unit On 2nd Channel

2 Times The Frequency, But 1/4 of The Surface

CD Possible, *CATV Implementation of MSTDM*

MSTDM ON A CELLULAR NETWORK
Eliminating The Second Channel

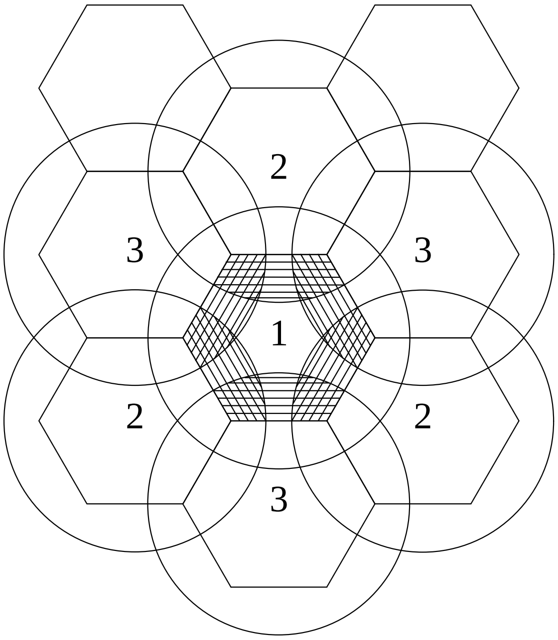
Communications: Mobile Units $\longleftarrow >$ Long Haul Net

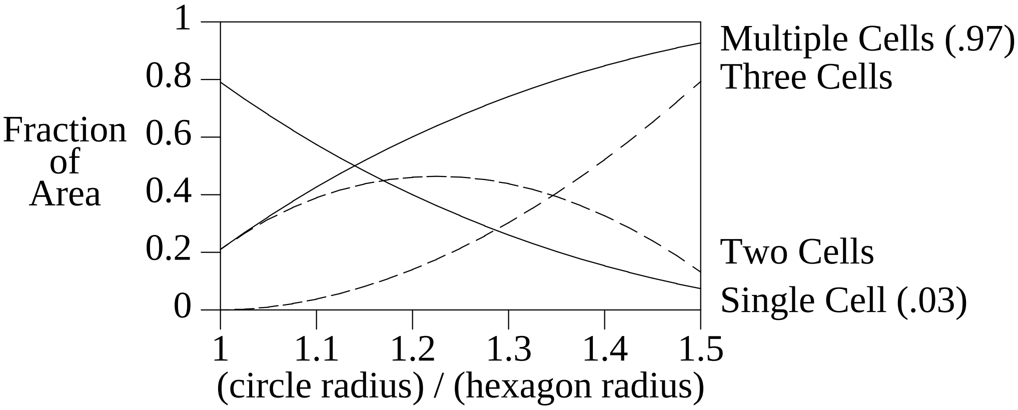
The Second Channel Is Used To Determine The State Of The Contention Channel

IMPLEMENTATION:

- *Multiplex The State Onto The Out Bound Channel*
  - Use DLE's To Interrupt The Out Bound Channel
- The Base Station Reports 3 Channel States:
  - Idle, Data Only, and Voice
  - Use Different Timing Extraction Signals To Distinguish Voice and Data
- Send ACK From The Base Station At The End Of A Packet.
  - Use To Detect Collision Between Data Terminals

USING OVERLAPPING AREAS





APPLICATIONS - *Any Cellular System*

1. Complete A Talk Spurt Before Changing Cells
2. Hysteresis For Changing Cells At The Boundaries
3. Redistribute Load From Oversubscribed Cells
4. Survive Base Station Failures

OVERSUBSCRIPTION - *PACKET NETWORKS*

Send The Voice Samples In Two MSTDM Channels
*Basic (***B***) And High (***H***) Quality*

WIRED MAN and OUTBOUND CELLULAR
- Discard **H** Packets First

INBOUND CELLULAR - *Level of Oversubscription*

Short Term - Order of a Talk Spurt

Send **B** → Closest Base Stations.

Send **H**, As Data Packets, → Lowest ρ Base Stations.
Packet Addresses Get All Of The Packets To The Agent

Long Term - Order of a Connection

First Reassign **H** Then **B** To A Lower ρ Base Station
Reassigned Signal Is Less Likely to Complete Talk Spurt

Drastic - Regional Rather Than Cellular
Instruct Specific Units To Curtail **H**
Drop The Connections For Specific Units

CONCLUSION

Packet Technologies Have Been Applied To Wireless Systems Since The Aloha System Was Deployed At The University Of Hawaii In The Late 60's.

At Present, The Main Applications Of Packet Radio Are Ad Hoc Networks In Military Systems And Wireless LAN's

The Architecture, Requirements, And Problems Of Cellular Radio Are Very Different Than The Present Packet Radio Networks

These Result In A Packet Radio Network That Is Very Different Than The Present Networks.

When Cell Sizes Become Smaller to Accommodate More Users, And Data Requirements Are Added
Packet Networks Are Preferrable To The Current Generation of Cellular Networks,

THE REAL IMPORTANCE OF PACKET CELLULAR RADIO

The 3rd Generation Cellular Standard Has Taken > 10 Years

It Predates The WEB

It Does Not Reflect The Real Use of Wideband Connectionless

Phone Companies Are Committing To IP

Separate Services and Xmission, As On The Internet

— Services No Longer Dependent on 64kbps
  Vertical Integration vrs Layered Architecture

— Introduce New Services Quickly
  POTS Revenue Isn't High Growth

— Bundled Services
  TV, Internet, Telephone